

EPA Automobile Emissions Test Facility

Site 3 Upgrade

Site Documentation

I. Introduction

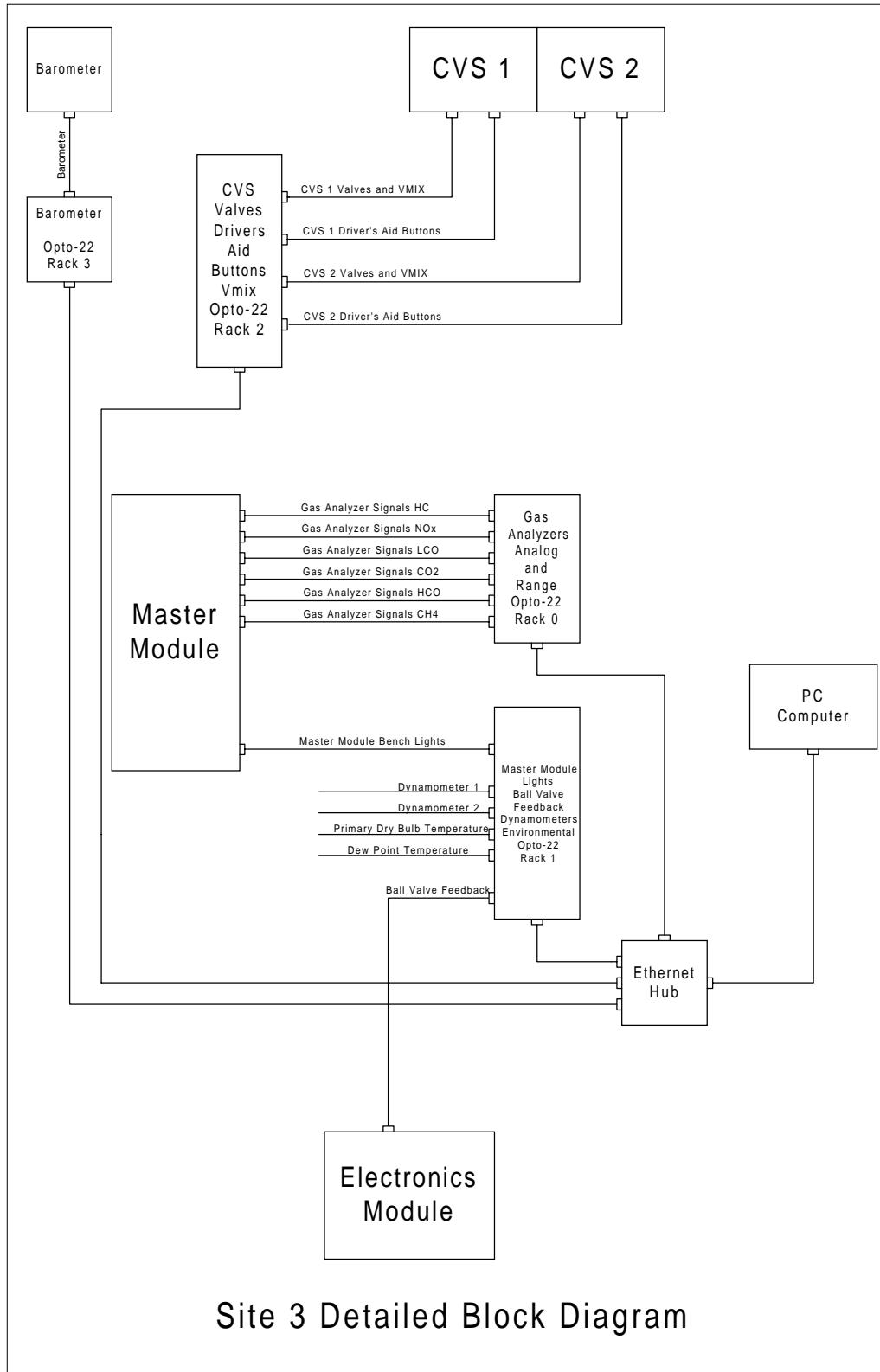
The EPA Test Site Modernization project has been developed to upgrade the equipment and software in the NVFEL Laboratory Computer System (LCS). Phase one of this project has been completed. Phase II of this effort includes the replacement of electronics in the Real-Time Peripherals (RTP) System Control and Data Acquisition (SCADA) and test site interfaces. The purpose of this effort is to implement the requirements of the EPA Test Site Modernization Project Phase II. Phase II includes two primary objectives: 1) the development of a RTP SCADA cabinet hardware replacement and 2) the development of a Site Interface electronic hardware replacement. This Design Document presents the design for an initial implementation at test site 3.

II. Hardware Detailed Design

This section will describe replacing the Real-Time-Processor (RTP) in the Site 3 Laboratory with data acquisition hardware from OPTO-22. The new hardware will acquire analog and digital data from gas analyzers and other electronic sources. It will also generate signals which will light indicator lights on the Master Modules.

Figure 1 shows the overall block diagram of Site 3. There are four OPTO-22 instruments which acquire data from the various sources. These four sites are linked together using an Ethernet Local Area Network. The Ethernet interfaces to a PC computer. This computer is used to acquire the data from the various OPTO-22 units.

Figure 1. Site 3 Block Diagram.



A. Site 3 Overall Block Diagram

The Overall Block Diagram shows the various elements of the OPTO-22 system delivered for Site 3. The OPTO-22 Analyzer Analog and Range unit interfaces to the Analyzers installed in the Master Module. It inputs the analog information and the Range Selection.

The OPTO-22 Lights, CVS Valve Feedback, Master Module Lights, Dynamometers, and Environmental input system interfaces to the Master Module and Electronics Module.

The OPTO-22 CVS Valves and Driver's Aid Buttons unit taps into the valve activation signals, and also the Driver's Aid buttons and reports the valve states and the states of the buttons.

The OPTO-22 Barometer unit interfaces to the Barometer to input the BCD digit information for the Barometer reading. The Barometer unit sends the data to all sites via an Ethernet cable.

Figure 2 – Analyzer General Functional Partition

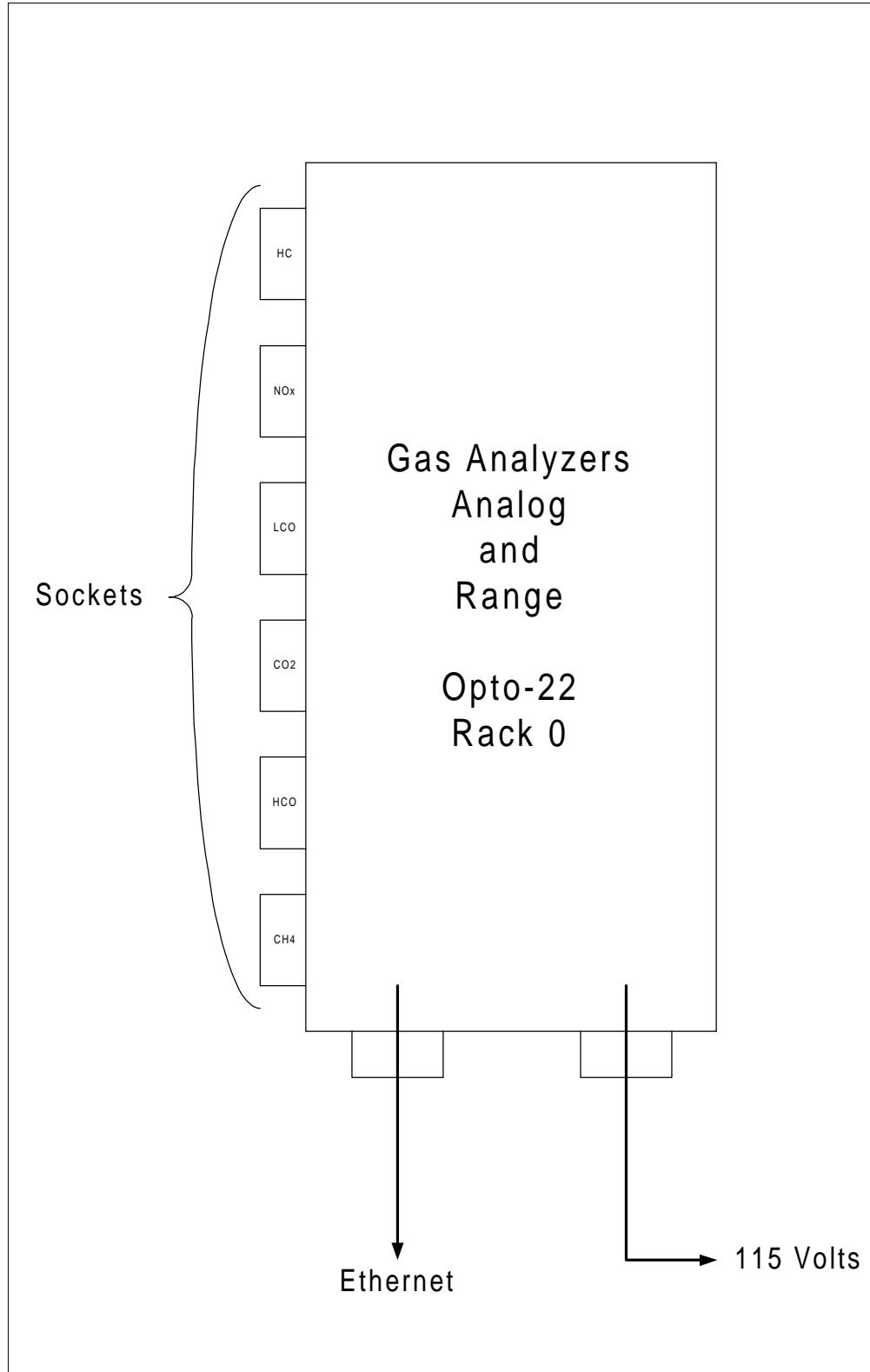


Figure 2 shows the general Functional Partition of the OPTO-22 Analyzer. The OPTO-22 unit is housed in a Hoffman box. This box is mounted on a wall. It has 6 Socket Connectors. These connectors are used with the existing Analyzer cables. The existing cables were unplugged from the Electronics Module, and plugged into this OPTO-22 unit.

Figure 3 – OPTO-22 Analyzer Detailed Functional Partition

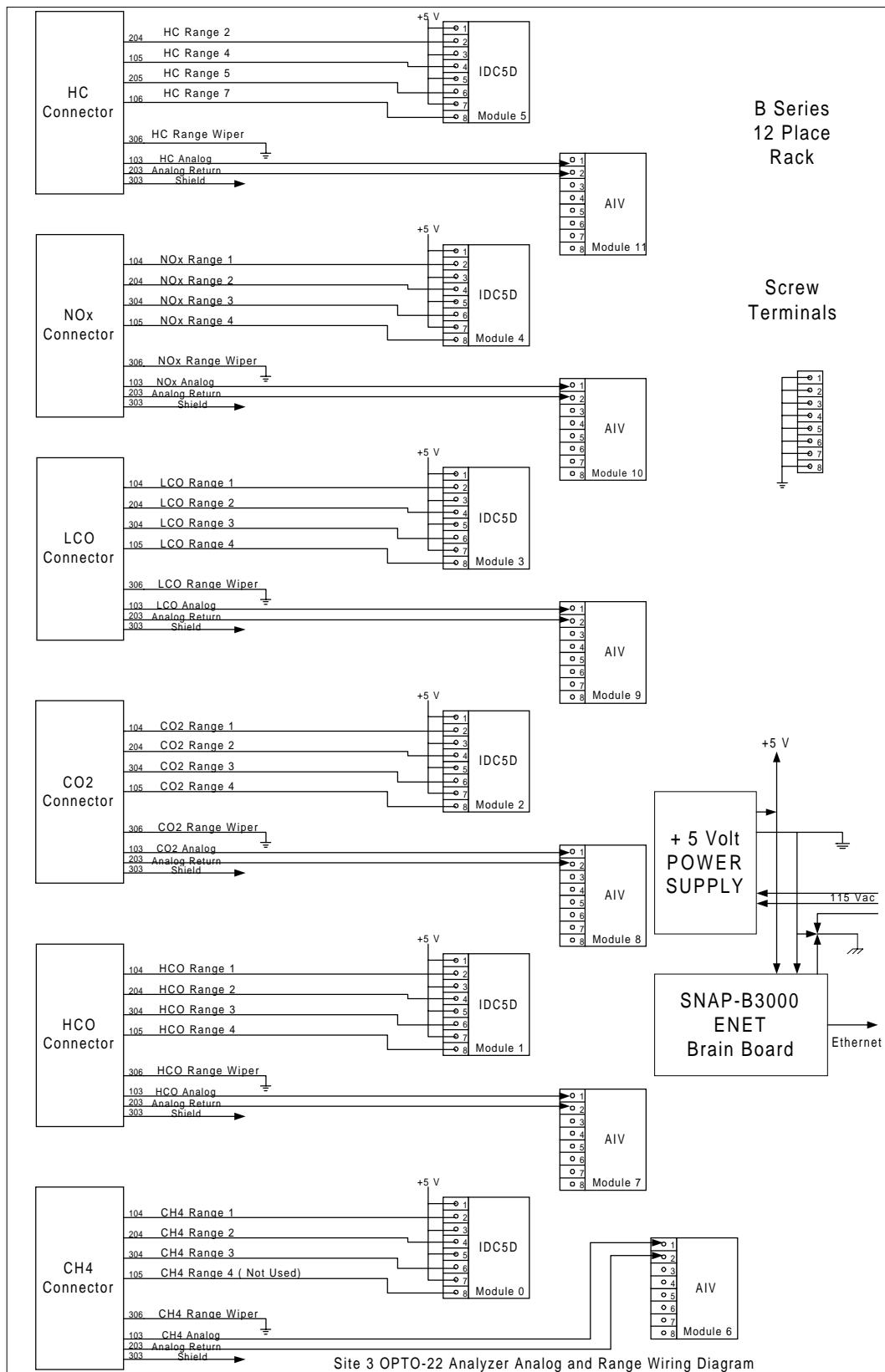


Figure 3 shows the detailed OPTO-22 Analyzer Functional Partition. The Analyzer connectors are wired to the appropriate OPTO-22 Module. Note that only four range signals are wired per Analyzer. Note also that each Analog input is wired to a separate Analog Input. Each Analog Module has an isolated input grounding system so the analog signals do not have to share a common ground with another analog signal.

The connectors will be mounted on an aluminum bulkhead plate on the wall of the Hoffman box. The unit has a self-contained 5 volt power supply for the OPTO unit. The 115 Volt power cord and the Ethernet cord comes out of the box with an appropriate strain relief housing.

Figure 4 - OPTO-22 Lights Functional Partition

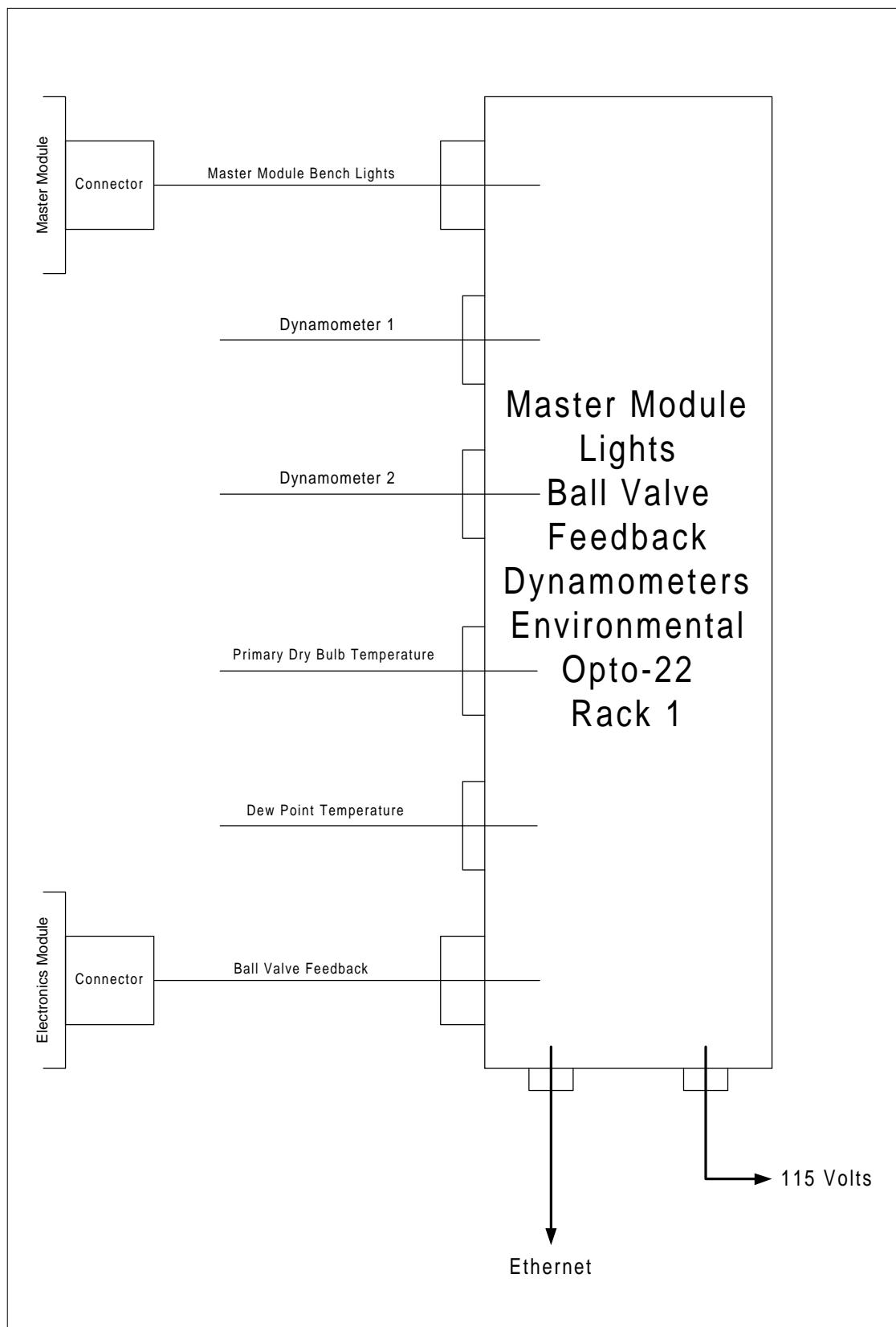


Figure 4 shows the OPTO-22 system which interfaces to the Master Module and the Electronics Module. It also houses the OPTO-22 modules which input data from the Dynamometers and the Temperature instruments.

The Master Module interface is a cable which comes out of the Hoffman Box with the appropriate Strain Relief and has a Connector which plugs into the Appropriate socket on the Master Module. This cable will contains the signal wires which light the Master Module Bench Lights. It also inputs one “Read Button” switch.

The Electronics Module interface is acable which comes out of the Hoffman Box with the appropriate Strain Relief and has a Connector which plugs into the appropriate socket on the Electronics Module. This cable contains the Valve Feedback signals generated by the Electronics Module. The wires currently going to the RTP unit in the lab for the Dynamometers and the two temperature signals were unwired from the RTP. These wires were fed into the Hoffman box and wired to the appropriate input module.

Figure 5 – OPTO-22 CVS Valve Detailed Functional Partition

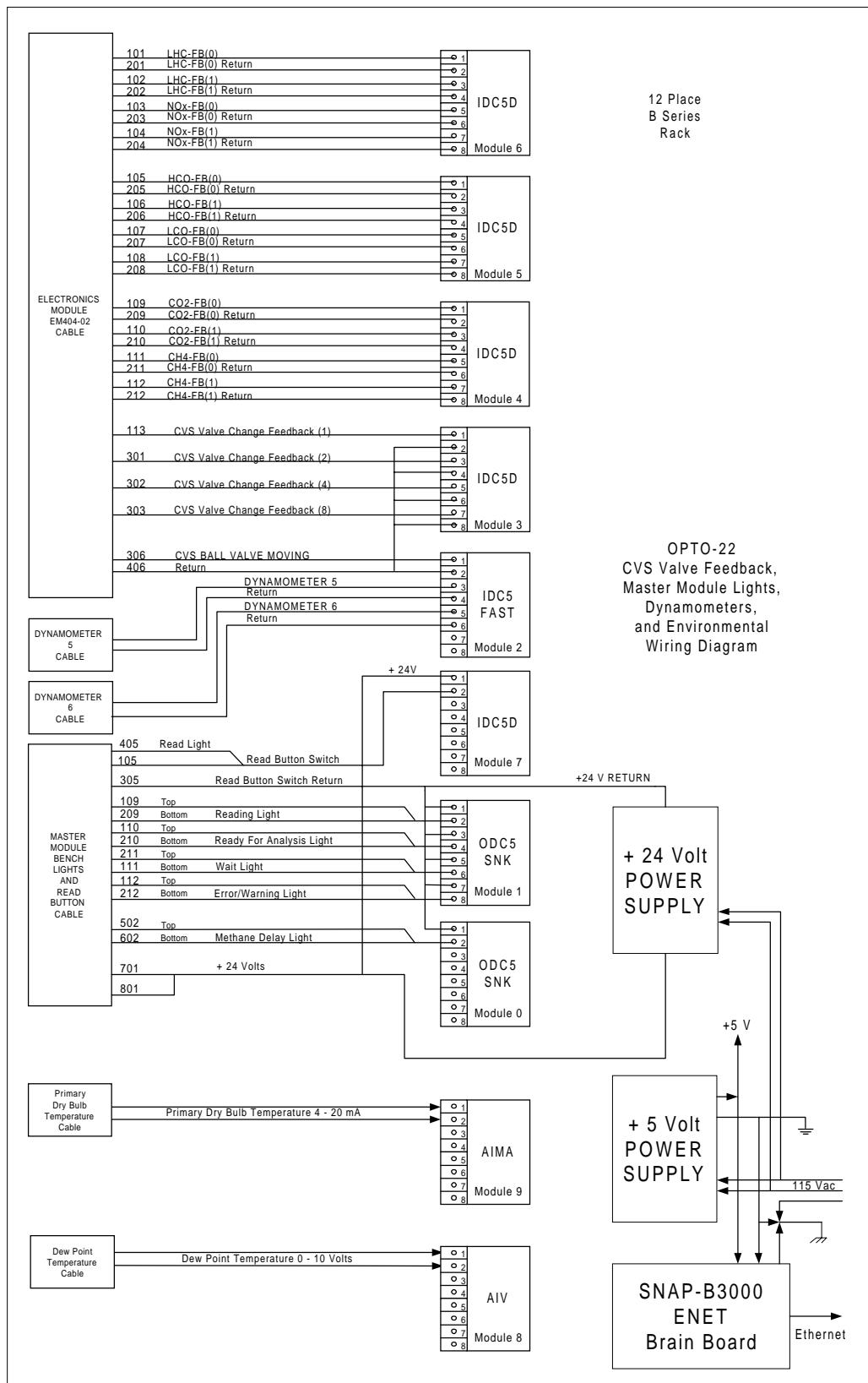


Figure 5 shows the Detailed Functional Partition for the CVS Valves Feedback OPTO-22 Unit. The Hoffman box contains the OPTO-22 unit along with a 5 Volt supply and a 24 Volt Power Supply to supply current for the lights. This diagram shows the pin numbers for the Electronics Module Connector and the Master Module Connector. Note also that there is a separate analog input module for the two temperature signals. This is necessary to provide a separate ground reference for each signal.

The Dynamometer and Temperature were unwired from the RTP and wired into this OPTO-22 unit during installation.

The 115 Volt power and Ethernet cables along with all other cables are routed out of the box with an appropriate strain relief. There are no bulkhead connectors on this OPTO-22 unit.

Figure 6 – OPTO-22 CVS Valves and Drivers Aid Buttons Functional Partition

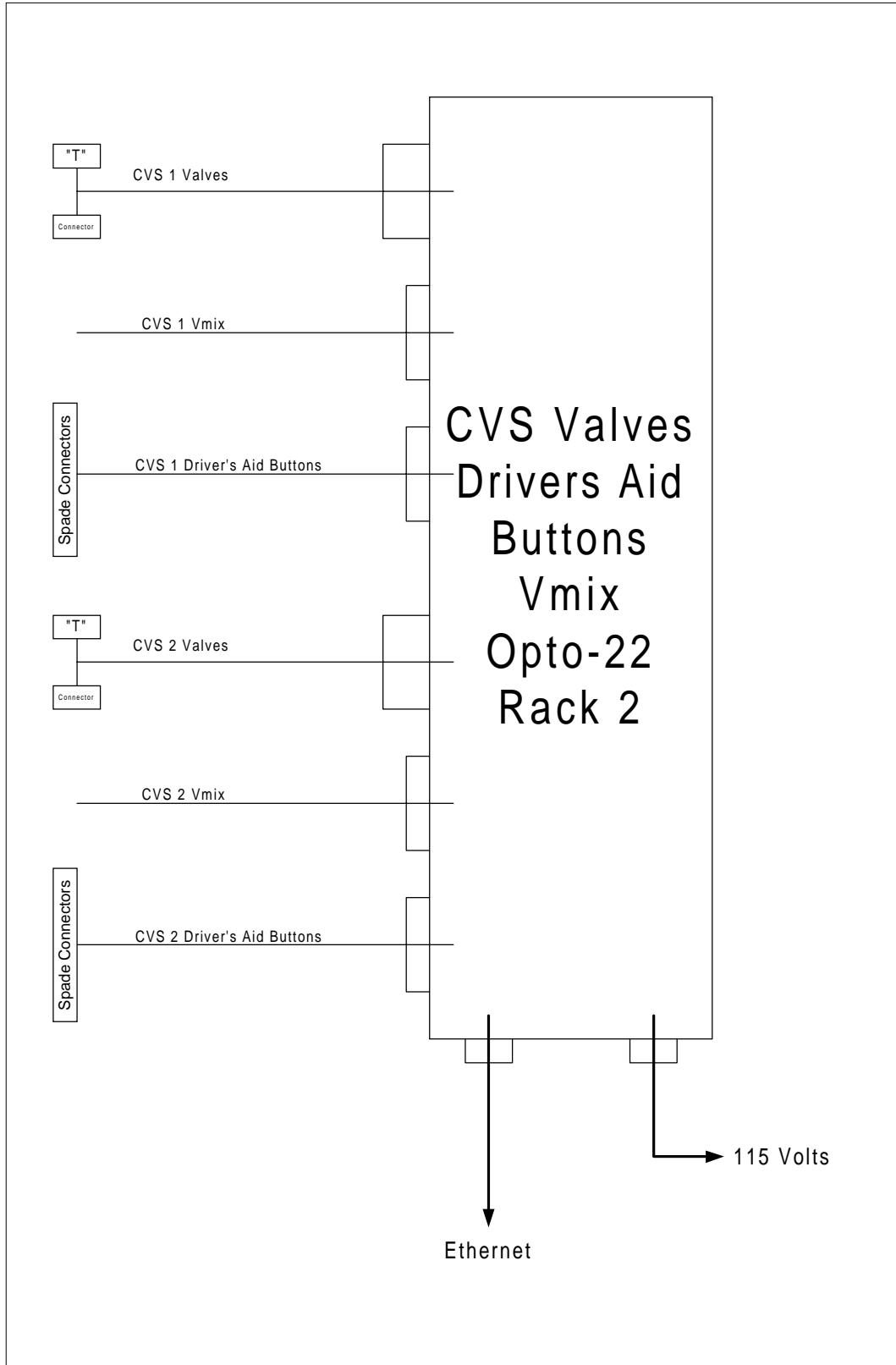


Figure 6 shows a Functional Partition of the CVS Valve and Driver's Aid Button Hoffman box. The signals associated with this OPTO-22 unit come from the CVS cabinets 1 and 2. The valve state signals are sensed using a "T" connector. The "T" connectors go in-line with the power lines that activate the valves. The OPTO-22 modules monitoring the valves sense when the valves are activated.

There are two sets of terminal strips in each CVS cabinet. These terminal strips provide the signals which determine the state of the Driver's Aid Buttons.

The VMIX signals were wired to the RTP unit. These cables were rerouted to this OPTO unit and wired to the appropriate input Module.

Figure 7 – OPTO-22 CVS Valve and Driver's Aid Buttons Detailed Functional Partition.

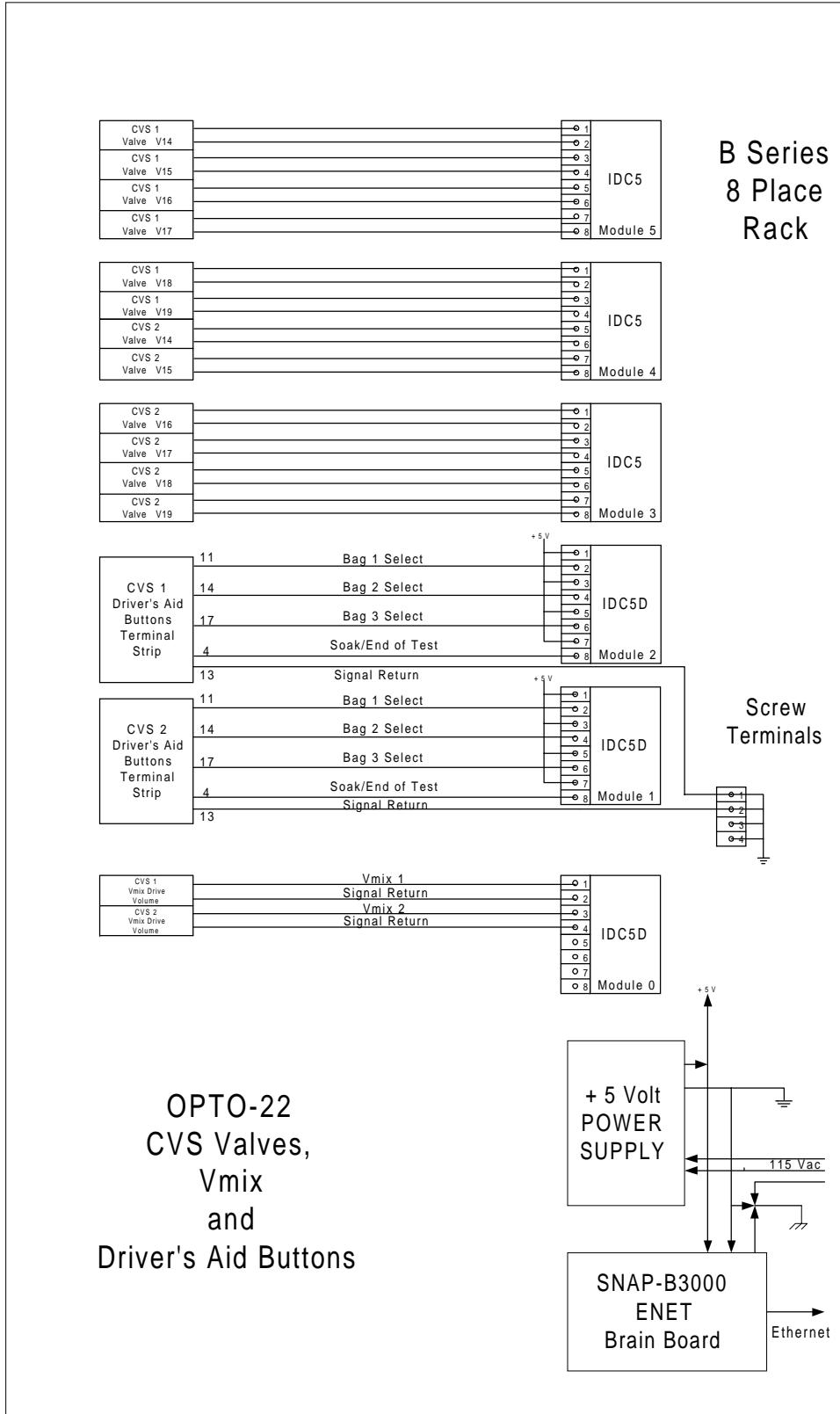


Figure 7 shows the detailed functional partition for the CVS Valves and Driver's aid buttons. Note that the input modules for the CVS Valves are 24 Volt modules. These modules use a higher threshold than the TTL version. The IDC5D module that receives the VMIX signals needs to be put into the counter mode and read as a counter, rather than a discrete input.

The screw terminal numbers are shown for the terminal strips associated with the Driver's Aid Buttons.

All cables running to this module use an appropriate strain relief. The cables running to the valves have a "T" connector on the ends to interface between the valves, and the power cables that drive the valves.

The ends of the cable to the Driver's Aid buttons have a terminal spade crimped on the end such that it can be wired into the screw terminals in the CVS cabinets.

Figure 8 – OPTO-22 Barometer Functional Partition

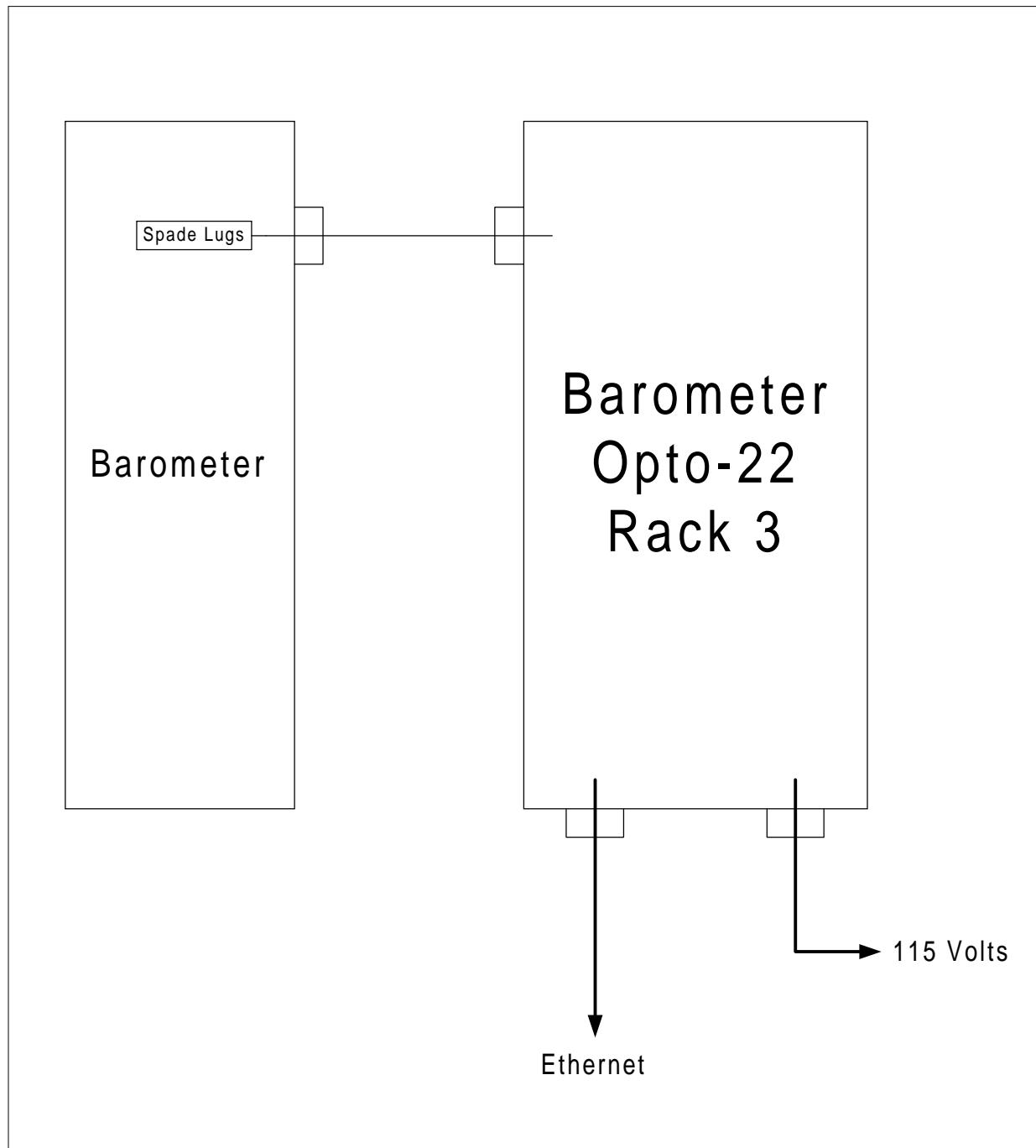
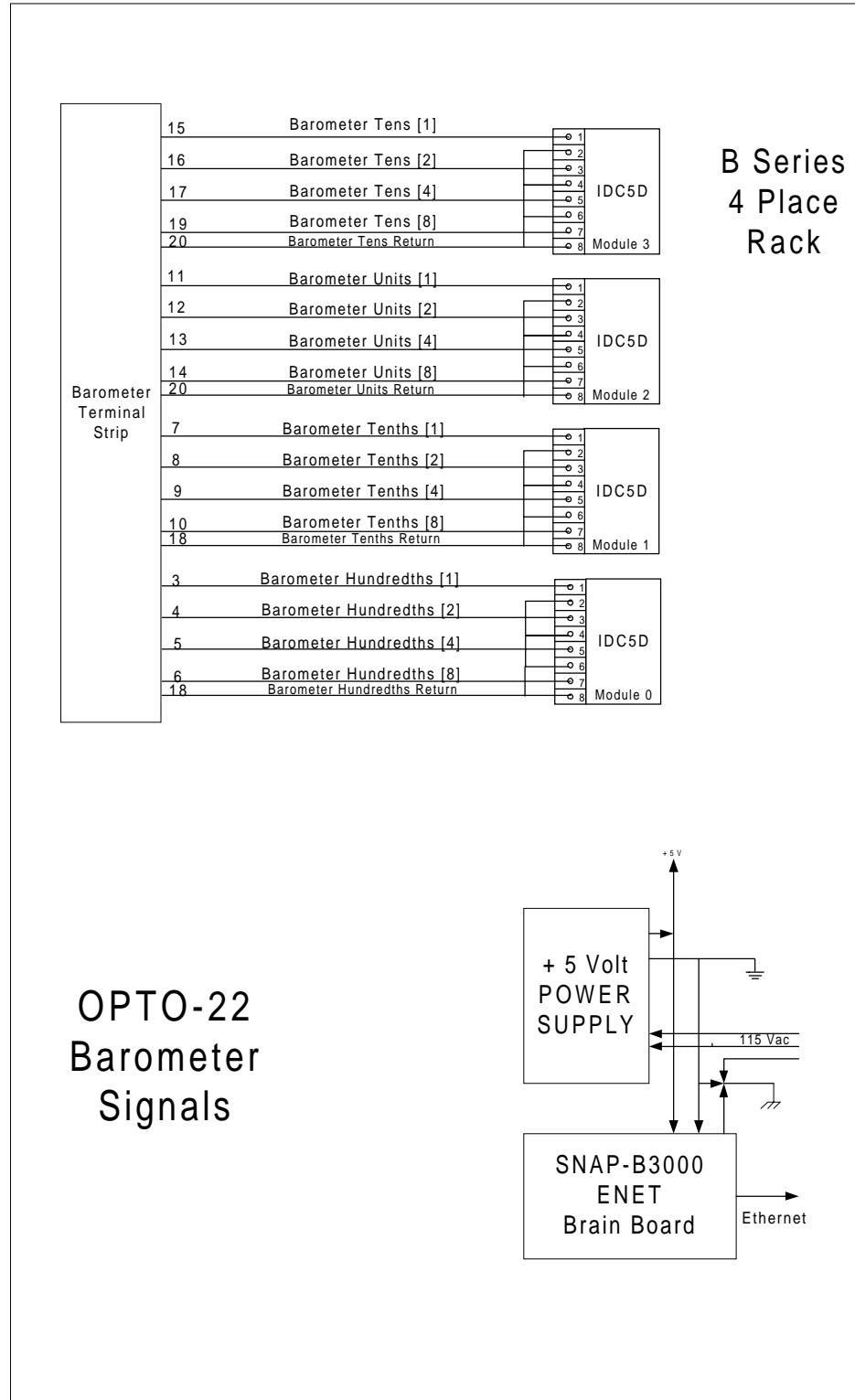


Figure 8 shows the Functional Partition for the Barometer Interface. The barometer is situated outside the laboratory site and currently interfaces to the RTP in each site. The OPTO-22 unit is mounted above the Barometer interface. The Ethernet cable routes to all of the sites. The OPTO digital inputs are routed to the appropriate signal on the terminal strips in the Barometer.

Figure 9 – OPTO-22 Barometer Detailed Functional Partition



The Barometer unit puts out BCD digital signals. These signals route to the IDC5D modules. The cable to these modules exits the Hoffman box with an appropriate Strain relief and runs to the Barometer box. The wires attach to a terminal strip in the Barometer box.

III. Software Design

A. Software Design Overview

The approach for modifying the Software program to support the new OPTO22 sensors is to impact as little of the exiting software as possible. Many generic RTP routines will be left in place even though they have RTP in their name or header block. All RTP functions will be removed and replaced with new OPTO22 routines. All analog, digital input, digital output, and counter common blocks and buffers will remain the same. The OPTO22 routines will load these routines with the same bit patterns as the RTP equipment.

B. OPTO22 Support Routines

The OPTO22 B3000 Brain Unit can be accessed through a set of library routines provided by OPTO22. These routines establish communication with the OPTO22 brains, read digital data points, write digital data points, read analog data points, and close communication with the brain units.

The necessary files are:

- O22SIOMM.h
- O22SIOMM.cpp
- O22SIOMMMXUtils.h
- O22SIOMMMXUtils.cpp

C. RTP Fortran Routines

No changes were made to the TAP software.

The following changes were made to the RTP software:

COMMSETUP: Replace this routine with a new routine to establish communications with the OPTO22 brain units.

RTPREAD: Replace this routine with a new routine to input data from the OPTO22 units. The input would be scaled and stored in the same currently used common blocks and buffers. See the Chart 1, Software Buffers and Signal Source Chart for a description of the signal sources

DIGOUT: Replace with a new routine to send digital outputs to the OPTO22 units. See Chart 2, Digital Output Chart, for a description of the output signals.

CALCCRC: Delete

COMMUNICAT: Delete

PREPARE: Delete

D. C++ Routines

Add new C++ routines to communicate with the OPTO22 units. These routines are in the file optoopen.cpp:

- Optoopen: a routine that will establishes communications with all OPTO22 Brain units
- Optodigitalread: a routine that inputs all digital values
- Optoanalogread: a routine that inputs all analog data points
- Optodigitalwrite: a routine that outputs all digital data points
- Optoclose: a routine that closes all OPTO22 Brain units
- OptoResetPulseCounters: a routine that resets the pulse counters to zero
- outputerrormsg: a routine that formats and outputs error messages to the terminal
- optoopenbrain: a routine that will establishes communications with a single OPTO22 Brain unit
- optopulsecounterread: a routine that inputs all counter data points
- digpointread: a routine that inputs a single counter value
- digbankreadarea: a routine that inputs digital values for a single brain
- setdigptstate: a routine that sets the value of a digital point
- optopulsecounterread: A routine that reads the pulse counters

Chart 1. SOFTWARE BUFFERS AND SIGNAL SOURCE CHART

EQDAT Value	Buffer Value	16 Bit Word Layout Bit numbering (16 15 . . . 3 2 1)	Signal Source	Rack	Module	Point	Value	Type
	ANLBUF(1)	-1800 (Emulate 9 Volts)						
EQDAT(1)	ANLBUF(2)	Bits 12 – 1 : HC value (0 – 10 v)	HC gas analyzer	0	11	44	0 - 10	Analog
EQDAT(2)	ANLBUF(3)	Bits 12 – 1 : NOx value (0 – 10 v)	NOx gas analyzer	0	10	40	0 - 10	Analog
EQDAT(3)	ANLBUF(4)	Bits 12 – 1 : CO2 value (0 – 10 v)	CO2 gas analyzer	0	8	32	0 - 10	Analog
EQDAT(4)	ANLBUF(5)	Bits 12 – 1 : LCO value (0 – 10 v)	LCO gas analyzer	0	9	36	0 - 10	Analog
EQDAT(5)	ANLBUF(6)	Bits 12 – 1 : HCO value (0 – 10 v)	HCO gas analyzer	0	7	28	0 - 10	Analog
EQDAT(6)	ANLBUF(7)	Bits 12 – 1 : CH4 value (0 – 10 v)	CH4 gas analyzer	0	6	24	0 - 10	Analog
EQDAT(7)	ANLBUF(8)	Bits 12 – 1 : Primary temp (4 – 20 mA)	Primary temp gage	1	9	36	4 – 20	Analog
EQDAT(8)	ANLBUF(9)	Bits 12 – 1 : Secondary temp (4 – 20 mA)	Sec. temp gage Not connected	-	-	-	Set to EQDAT(7)	Analog
EQDAT(9)	ANLBUF(10)	Bits 12 – 1 : Dew point (0 – 10 v)	Dew point gage	1	8	32	0 - 10	Analog
EQDAT(10)	-	Loaded from EQDAT(18)	-	-	-	-	-	-
EQDAT(11)	DIGBUF(1)	Bits: 16 15 14: HC range position 13 12 11: NOx range position 10 09 08: CO2 range position 07 06 05: LCO range position 04 03 02: HCO range position 01 : 0	Range switch pos: HC NOx CO2 LCO HCO unused	0 0 0 0 0	5 4 3 2 1	20-23 16-19 12-15 08-11 04-07	Switch position 1-4	Digital
EQDAT(12)	DIGBUF(2)	Bits: 16 15 14: CH4 range position 13 – 12: HC switch position 11 – 10: NOx switch position 09 – 08: LCO switch position 07 – 06: CO2 switch position 05 – 04: HCO switch position 03 – 02: CH4 switch position 01: 0	CH4 HC valve NOx valve LCO valve CO2 valve HCO valve CH4 valve unused	0 1 1 1 1 1 1	0 6 6 5 4 5 4	0-3 25,24 27,26 23,22 17,16 21,20 19,18	0: OFF 1: ZERO 2: ANALYZE 3: SPAN	Digital

EQDAT Value	Buffer Value	16 Bit Word Layout Bit numbering (16 15 . . . 3 2 1)	Signal Source	Rack	Module	Point	Value	Type
EQDAT(13)	DIGBUF(3)	Bits: 16 – 14: 0 13 – 11: Ball valve select 10 : 1 09 : READ button 08 : Ball valve not moving 07 – 01: 0	Unused PIV feedback: Always 1 READ button PIV feedback unused	1 1 1	3 7 3	14-12 28 8	001: FPC 010: D006 SAM 011: D005 SAM 100: D006 B/G 101: D005 B/G 0: off 1:on	Digital
EQDAT(14)	DIGBUF(4)	Bits: 16: BG1 CVS 2 15: BG2 CVS 2 14: BG3 CVS 2 13: BG4 CVS 2 12: BG5 CVS 2 11: BG6 CVS 2 10: BG1 CVS 1 09: BG1 CVS 1 08: BG1 CVS 1 07: BG1 CVS 1 06: BG1 CVS 1 05: BG1 CVS 1 04 – 01: 0	CVS valve feedback buttons: CVS 2 V14 CVS 2 V15 CVS 2 V16 CVS 2 V17 CVS 2 V18 CVS 2 V19 CVS 1 V14 CVS 1 V15 CVS 1 V16 CVS 1 V17 CVS 1 V18 CVS 1 V19 unused	2 2 2 2 2 2 2 2 2 2 2 2 2	4 4 3 3 3 3 5 5 5 5 4 4	18 19 12 13 14 15 20 21 22 23 16 17	0:off 1:on	Digital
EQDAT(15)	DIGBUF(5)	Unused	-	-	-	-	-	-
EQDAT(16)	DIGBUF(6)	Bits: 16: BAG1 15: BAG2 14: SOAK/EOT 13: BAG3 12-01: 0	CVS1 DA buttons BAG1 BAG 2 SOAK/EOT BAG3 Unused	2 2 2 2	1 1 1 1	4 5 7 6	0: off 1:on	Digital

EQDAT Value	Buffer Value	16 Bit Word Layout Bit numbering (16 15 . . . 3 2 1)	Signal Source	Rack	Module	Point	Value	Type
EQDAT(17)	DIGBUG(7)	Bits: 16: BAG1 15: BAG2 14: SOAK/EOT 13: BAG3 12-01: 0	CVS2 DA buttons BAG1 BAG 2 SOAK/EOT BAG3 Unused	2 2 2 2 2	2 2 2 2 2	8 9 11 10	0: off 1:on	Digital
EQDAT(18)	DIGBUF(8)	Bits: 16-13: BCD Digit 4 10s 12-09: BCD Digit 3 units 08-05: BCD Digit 2 tenths 04-01: BCD Digit 1 hundredth	Barometer	3 3 3 3	3 2 1 0	15-12 11-08 07-04 03-00	Binary Coded Decimal 4 digit number	Digital
EQDAT(19)	PCBUF(1)	Bits: 16-1: D005 Roll revs count	Dyno 5	1	2	9	Count value	Counter
EQDAT(20)	PCBUF(2)	Bits: 16-1: D006 Rollrevs count	Dyno 6	1	2	10	Count value	Counter
EQDAT(21)	PCBUF(3)	Bits: 16-1: CVS1 Vmix	CVS1	2	0	0	Count value	Counter
EQDAT(22)	PCBUF(4)	Bits: 16-1: CVS2 Vmix	CVS2	2	0	1	Count value	Counter

Chart 2. DIGITAL OUTPUT CHART

	Buffer Value	16 Bit Word Layout Bit numbering (16 15 . . . 3 2 1)			Signal Destination	Rack	Module	Point	Value	Type
Digital Output Word	DIGOUT	ID	Bit Pos	Value	Digital outputs					Digital Outputs
		1	16	READING	READ LIGHT	1	1	4	0:off 1:on	
		2	15	RFA READY	RFA LIGHT	1	1	5		
		3	14	WAIT	WAIT LIGHT	1	1	6		
		4	13	WARN	WARN LIGHT	1	1	7		
		5	14	BUZZER	No connection					
		6	09	CH4DLY	CH4DLY LIGHT	1	0	0		
		12-10, 08-01: 0			Unused					

IV. Detailed Site Modification Plan

A. Connecting to the Master Module Cables

The Analyzer cables currently run from the Master Module to the Electronics Module. Apparently, they are not used in the Electronics Module, but are passed through to the RTP cabinet. Our plan is to unplug the Analyzer cables from the Electronics Module, and run the cables to a set of connectors on the OPTO-22 Analyzer unit.

The RTP currently generates signals which illuminate lights on the Master Module. We will unplug this cable, and build our own cable from the OPTO-22 unit. The OPTO-22 cable will have a connector which mates to the socket on the Master Module. The Socket designator is MM406-01.

B. Connecting to the Electronic Module Cables

The Electronics Module circuitry conditions the valve signals and creates Ball Valve Feedback signals. These signals currently run from the Electronics Module to the RTP. We will unplug this cable and build a similar cable to the OPTO-22 unit with a connector to plug into the Electronics Module Socket designated EM404-02.

C. Connecting to the CVS Cabinets One and Two

The CVS Cabinets One and Two contain Ball Valves. We will build a “T” connector for six valves per cabinet. This will allow us to monitor the energized state of these valves. We used a shielded twisted pair wire for each valve. These wires will run through an appropriate strain relief on the OPTO-22 Hoffman box and will be wired directly to a 24 volt digital input module.

D. Connecting to the Barometer

We delivered a small OPTO-22 unit mounted in a Hoffman Box near the current Barometer. We ran a multi-stranded cable from the OPTO-22 Hoffman Box to the Barometer box. We attached the OPTO-22 side of the cable directly to the digital input modules. The barometer end of the cable is attached to the appropriate terminal strip connectors that have the appropriate barometer signals.

E. Connecting to the Dynamometers

The Dynamometers currently have a cable running to the RTP. We removed the cables from the RTP and wired them directly into OPTO-22 unit.

F. Connecting to the Environmental Temperature Information

The Environmental Temperature signals currently have cables running directly to the RTP. We will remove the cables from the RTP and wire them directly into the OPTO-22 unit.

G. Connecting to the Driver's Aid Buttons

The CVS Cabinets each contain a set of two terminal strips which allow access to the Driver's Aid Button signals. We used a multi-stranded cable with spade lugs to attach to the terminal strips. The other end of the cable will be routed into the OPTO-22 Hoffman box and will be wired directly to the digital input modules. The CVS terminal strip designation is:
CVS TO RTP TB28/29.

H. Ethernet Hub Connections

Each of the four OPTO-22 Sites will connect to an Ethernet Hub. The Host PC will also connect to the HUB. The PC will be able to communicate through this Ethernet interface to the OPTO-22 sites to exchange information. The location of the HUB is TBD.

V. Software Revision Plan

A. Initial Setup Tasks

The first setup step needed to modifying the software is to create a copy of the EPA Visual C++/FORTRAN production project and name it OPTO22. This new project should be placed at the same subdirectory level as the production EPA project.

B. Installing OPTO22 Support Routines

The following OPTO22 C++ routines should be copied to the OPTO22 / Rtp subdirectory:

- O22SIOMM.h
- O22SIOMM.cpp
- O22SIOMMXUtils.h
- O22SIOXUtils.cpp
- O22SIOSTRUCT.h

Add the .cpp routines to the Visual Development Project under “C Source Files”.

Add the .h files to “C Header Files”.

C. Modifying Visual FORTRAN/C++ Environment Settings

Within the Visual Development environment, the following options should be set:

Select “Project” from the menu bar

Select “Settings” menu item

Select the “Link” tab

Set the entry for “Object/library routine” to “ws2_32.lib”

This library is needed to support calls within the OPT22 support routines.

D. Modifying RTP FORTRAN Routines

Copy the following files to the E01rh subdirectory:

- Commsetu.f (replace old file)
- Digout.f (replace old file)
- Rtpread.f (replace old file)

Delete the following routines:

- Communicat.f
- Calccrc.f
- Prepare.f

E. Modifying C++ Routines

Copy the following files to the Rtp subdirectory:

- Optoopen.cpp
- Rtp.rc (replace old file)

The optoopen.cpp routine should then be included into the project “C Source Files.”

F. Compiling and Linking

Following the completion of steps A – E, select “Rebuild All” under the “Project” Menu. The project should then be ready to execute.

When the project executes correctly, change the environment from DEBUG to RELEASE and rebuild the final executable file.

G. Setting OPTO22 / PC IP Addresses

The OPTO22 and EPA host PC IP addresses must be set so that they are compatible. The OPTO22 address can be set by using the OPTO22 supplied utility routines. The address and mask can then be set to match the address of the EPA host machine. The OPTO22 IP address are set for:

Brain Unit Rack 0 204.47.209.150

Brain Unit Rack 1 204.47.209.151

Brain Unit Rack 2 204.47.209.152

Brain Unit Rack 3 204.47.209.153

OPTO22 IP masks are set for: 255.255.0.0

Refer to Chapter 3 of “SNAP ETHERNET BRAIN USERS’S GUIDE” for the instructions on assigning IP Addresses. The IP Addresses must be static and cannot be assigned by a DHCP server.

H. Configuring Digital Output and Digital Counter Module Points

The following points should be configured as Digital Output points using the OPTO22 supplied utility routines or Web Browser:

Rack Module Point

1	0	0
1	1	4
1	1	5
1	1	6
1	1	7

Also, the following points should be configured as Digital Point Counters using the OPTO22 supplied software or Web Browser:

Rack Module Point

1	2	9
1	2	10
2	0	0
2	0	1

Refer to Chapter 4 of “SNAP ETHERNET BRAIN USERS’S GUIDE” for the instructions on connecting to the OPTO 22 Brain web server.

Refer to Chapter 3 of “SNAP ETHERNET BRAIN USERS’S GUIDE” for the instructions on configuring I/O Points.

Follow these steps to configure a digital input:

1. Connect to the OPTO 22 Brain web server
2. Click on the “Click here to begin” link to go to the home page
3. Select “Configure Point” from the menu
4. Select the point to configure
5. Select “Digital Input” from the “Point Type” pull down menu
6. Press the “Configure Point” button at the bottom of the page

Follow these steps to configure a digital output:

1. Connect to the OPTO 22 Brain web server
2. Click on the “Click here to begin” link to go to the home page
3. Select “Configure Point” from the menu
4. Select the point to configure
5. Select “Digital Output” from the “Point Type” pull down menu
6. Press the “Configure Point” button at the bottom of the page

Follow these steps to configure an analog input:

1. Connect to the OPTO 22 Brain web server
2. Click on the “Click here to begin” link to go to the home page
3. Select “Configure Point” from the menu
4. Select the point to configure
5. Select the analog output type from the “Point Type” pull down menu matching the OPTO 22 input module
6. Press the “Configure Point” button at the bottom of the page

Follow these steps to configure an analog output:

1. Connect to the OPTO 22 Brain web server
2. Click on the “Click here to begin” link to go to the home page
3. Select “Configure Point” from the menu
4. Select the point to configure
5. Select the analog output type from the “Point Type” pull down menu matching the OPTO 22 output module
6. Press the “Configure Point” button at the bottom of the page

Follow these steps to configure a counter:

1. Connect to the OPTO 22 Brain web server
2. Click on the “Click here to begin” link to go to the home page
3. Select “Configure Point” from the menu
4. Select the point to configure
5. Select “Digital Input” from the “Point Type” pull down menu
6. Set the “Point Feature” value to 1 (one)
7. Press the “Configure Point” button at the bottom of the page
8. Select “Digital Point Write” from the menu
9. Select the point to configure
10. Select “Activate” from the “Activate/Deactivate Counter” pull down menu
11. Press the “Write to Point” button at the bottom of the page

VI. Detailed Offsite test Plan

A. Assembly of OPTO units in Hoffman Boxes in Ogden

We will mount the OPTO-22 units in Hoffman Boxes. We will machine the Hoffman boxes with the appropriate access holes. Each hole will have an appropriate strain relief.

B. Testing Assembly with Simulated Signals in Ogden

Each Hoffman OPTO unit will be tested with simulated inputs and outputs to ensure that each OPTO module is functioning properly.

C. Software Testing with Simulated Signals in Ogden

The software interface to each OPTO-22 unit will be tested in Ogden. Each module in the units will be tested with a simulated input.

VII. Detailed Site Installation Plan for Site 3

Each OPTO-22 Hoffman box is mounted to a wall in site 3. The mounting of the Hoffman boxes was done by EPA personnel. We assisted in rerouting the RTP cables to the appropriate OPTO-22 unit. We provided the cables for interfacing to the Valves, and terminal strips. Attaching these cables to the Valves and Terminal Strips was done by EPA personnel with TRW assistance.

OPTO-22 Hardware Detailed Design

Opto Site		Rack Number		Cable Group Alpha 2216C – 2241C			
Gas Analyzer		0		HC Connector			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
HC Range 2	HC	204	Red	IDC5D	5	2	Digital
HC Range 4	HC	105	White	IDC5D	5	4	Digital
HC Range 5	HC	205	Green	IDC5D	5	6	Digital
HC Range 7	HC	106	Blue	IDC5D	5	8	Digital
HC Range Wiper	HC	306	Black	Screw Terminal Ground			
HC Analog	HC	103	Red	AIV	11	1	Analog
HC Analog Return	HC	203	Black	AIV	11	2	Analog
HC Shield	HC	303	Shield				

Opto Site		Rack Number		Cable Group Alpha 2216C – 2241C			
Gas Analyzer		0		NOx Connector			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
NOx Range 1	NOx	104	Red	IDC5D	4	2	Digital
NOx Range 2	NOx	204	White	IDC5D	4	4	Digital
NOx Range 3	NOx	304	Green	IDC5D	4	6	Digital
NOx Range 4	NOx	105	Blue	IDC5D	4	8	Digital
NOx Range Wiper	NOx	306	Black	Screw Terminal Ground			
NOx Analog	NOx	103	Red	AIV	10	1	Analog
NOx Analog Return	NOx	203	Black	AIV	10	2	Analog
NOx Shield	NOx	303	Shield				

Opto Site		Rack Number		Cable Group Alpha 2216C – 2241C			
Gas Analyzer		0		LCO Connector			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
LCO Range 1	LCO	104	Red	IDC5D	3	2	Digital
LCO Range 2	LCO	204	White	IDC5D	3	4	Digital
LCO Range 3	LCO	304	Green	IDC5D	3	6	Digital
LCO Range 4	LCO	105	Blue	IDC5D	3	8	Digital
LCO Range Wiper	LCO	306	Black	Screw Terminal Ground			
LCO Analog	LCO	103	Red	AIV	9	1	Analog
LCO Analog Return	LCO	203	Black	AIV	9	2	Analog
LCO Shield	LCO	303	Shield				

Opto Site		Rack Number		Cable Group Alpha 2216C – 2241C			
Gas Analyzer		0		CO2 Connector			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
CO2 Range 1	CO2	104	Red	IDC5D	2	2	Digital
CO2 Range 2	CO2	204	White	IDC5D	2	4	Digital
CO2 Range 3	CO2	304	Green	IDC5D	2	6	Digital
CO2 Range 4	CO2	105	Blue	IDC5D	2	8	Digital
CO2 Range Wiper	CO2	306	Black	Screw Terminal Ground			
CO2 Analog	CO2	103	Red	AIV	8	1	Analog
CO2 Analog Return	CO2	203	Black	AIV	8	2	Analog
CO2 Shield	CO2	303	Shield				

Opto Site	Rack Number	Cable Group Alpha 2216C – 2241C
Gas Analyzer	0	HCO Connector

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
HCO Range 1	HCO	104	Red	IDC5D	1	2	Digital
HCO Range 2	HCO	204	White	IDC5D	1	4	Digital
HCO Range 3	HCO	304	Green	IDC5D	1	6	Digital
HCO Range 4	HCO	105	Blue	IDC5D	1	8	Digital
HCO Range Wiper	HCO	306	Black	Screw Terminal Ground			
HCO Analog	HCO	103	Red	AIV	7	1	Analog
HCO Analog Return	HCO	203	Black	AIV	7	2	Analog
HCO Shield	HCO	303	Shield				

Opto Site	Rack Number	Cable Group Alpha 2216C – 2241C
Gas Analyzer	0	CH4 Connector

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
CH4 Range 1	CH4	104	Red	IDC5D	0	2	Digital
CH4 Range 2	CH4	204	White	IDC5D	0	4	Digital
CH4 Range 3	CH4	304	Green	IDC5D	0	6	Digital
CH4 Range 4	CH4	105	Blue	IDC5D	0	8	Digital
CH4 Range Wiper	CH4	306	Black	Screw Terminal Ground			
CH4 Analog	CH4	103	Red	AIV	6	1	Analog
CH4 Analog Return	CH4	203	Black	AIV	6	2	Analog
CH4 Shield	CH4	303	Shield				

Opto Site		Rack Number	Cable Group Alpha 2919/19C			
CVS Feedback		1	EM 404-02 Cable			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
HC-FB(0)	EM402-02	101	Red	IDC5D	6	1	Digital
HC-FB(0) Return	EM404-02	201	Black	IDC5D	6	2	Digital
HC-FB(1)	EM402-02	102	White	IDC5D	6	3	Digital
HC-FB(1) Return	EM404-02	202	Black	IDC5D	6	4	Digital
NOx-FB(0)	EM402-02	103	Green	IDC5D	6	5	Digital
NOx-FB(0) Return	EM404-02	203	Black	IDC5D	6	6	Digital
NOx-FB(1)	EM402-02	104	Blue	IDC5D	6	7	Digital
NOx-FB(1) Return	EM404-02	204	Black	IDC5D	6	8	Digital
HCO-FB(0)	EM402-02	105	Brown	IDC5D	5	1	Digital
HCO-FB(0) Return	EM404-02	205	Black	IDC5D	5	2	Digital
HCO-FB(1)	EM402-02	106	Yellow	IDC5D	5	3	Digital
HCO-FB(1) Return	EM404-02	206	Black	IDC5D	5	4	Digital
LCO-FB(0)	EM402-02	107	Orange	IDC5D	5	5	Digital
LCO-FB(0) Return	EM404-02	207	Black	IDC5D	5	6	Digital
LCO-FB(1)	EM402-02	108	Green	IDC5D	5	7	Digital
LCO-FB(1) Return	EM404-02	208	Red	IDC5D	5	8	Digital
CO2-FB(0)	EM402-02	109	White	IDC5D	4	1	Digital
CO2-FB(0) Return	EM404-02	209	Red	IDC5D	4	2	Digital
CO2-FB(1)	EM402-02	110	Blue	IDC5D	4	3	Digital
CO2-FB(1) Return	EM404-02	210	Red	IDC5D	4	4	Digital
CH4-FB(0)	EM402-02	111	Yellow	IDC5D	4	5	Digital
CH4-FB(0) Return	EM404-02	211	Red	IDC5D	4	6	Digital
CH4-FB(1)	EM404-02	112	Brown	IDC5D	4	7	Digital
CH4-FB(1) Return	EM404-02	212	Red	IDC5D	4	8	Digital
CVS Valve Change FB (1)	EM404-02	113	Orange	IDC5D	3	1	Digital
Return	EM404-02	406	Red	IDC5D	3	2	Digital
CVS Valve Change FB (2)	EM404-02	301	Blue	IDC5D	3	3	Digital
Return	EM404-02	406	Green	IDC5D	3	4	Digital
CVS Valve Change FB (4)	EM404-02	302	White	IDC5D	3	5	Digital
Return	EM404-02	406	Green	IDC5D	3	6	Digital
CVS Valve Change FB (8)	EM404-02	303	Brown	IDC5D	3	7	Digital
Return	EM404-02	406	Green	IDC5D	3	8	Digital
CVS Ball Valve Moving	EM404-02	306	Orange	IDC5D	2	1	Digital
Return	EM404-02	406	Green	IDC5D	2	2	Digital

Note: Pin 406 on EM404-02 should be bussed to Module 3 pins 2,4,6, 8 and Module 2 Pin 2.

Opto Site		Rack Number		Cable Group			
CVS Feedback		1		Dynamometer Cable 5			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Dynamometer 5			White	IDC5F	2	3	Digital Counter
Dynamometer 5 Return			Black	IDC5F	2	4	Digital Counter

Opto Site		Rack Number		Cable Group			
CVS Feedback		1		Dynamometer Cable 6			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Dynamometer 6			White	IDC5F	2	5	Digital Counter
Dynamometer 6 Return			Black	IDC5F	2	6	Digital Counter

Opto Site		Rack Number		Cable Group			
CVS Feedback		1		Temperature			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Temperature			White	AIMA	8	1	Analog
Return			Black	AIMA	8	2	Analog

Opto Site		Rack Number		Cable Group			
CVS Feedback		1		Dew Point			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Dew Point			White	AIV	7	1	Analog
Return			Black	AIV	7	2	Analog

Opto Site			Rack Number		Cable Group Alpha 2219C		
CVS Feedback			1		Master Module Lights MM406-01		
Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Reading Light	MM406-01	209 - Bottom	Red	ODC5SNK	1	2	Digital
		109 - Top	Black	ODC5SNK	1	2	Digital
Ready for Analysis Light	MM406-01	210 - Bottom	White	ODC5SNK	1	4	Digital
		110 - Top	Black	ODC5SNK	1	4	Digital
Wait Light	MM406-01	211 - Top	Green	ODC5SNK	1	6	Digital
		111 - Bottom	Black	ODC5SNK	1	6	Digital
Error/Warning Light	MM406-01	212 - Bottom	Blue	ODC5SNK	1	8	Digital
		112 - Top	Black	ODC5SNK	1	8	Digital
Methane Delay Light	MM406-01	502 - Top	Brown	ODC5SNK	0	2	Digital
		602 - Bottom	Black	ODC5SNK	0	2	Digital
24 Volt Source	MM406-01	701	Yellow	Terminal Strip			+24V
24 Volt Source	MM406-01	801	Black	Terminal Strip			+24V
Read Button Switch	MM406-01	105 / 405 - Light	Orange	IDC5D	7	2	Digital
			Black	IDC5D	7	2	Digital
Read Button Return	MM406-01	305	Green	24 volt Return			Digital

Notes: MM406-01 Pin 305 should be tied to 24 Volt return on the terminal wire strip. Module 7 Pin17 should be tied to +24V. MM406-01 Pins 701 and 801 should be tied to +24 Volts on the terminal Wire Strip. Note that pins 105 and 405 are tied together on Module 7 Pin 2.

Opto Site		Rack Number		Cable Group Alpha 2241C			
CVS Valves and Drivers Aid Buttons		2		CVS 1			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
CVS 1 Valve V14	V14 - T	1	Red	IDC5	5	1	Digital
Return	V14 - T	2	Black	IDC5	5	2	Digital
CVS 1 Valve V15	V15 - T	1	Red	IDC5	5	3	Digital
Return	V15 - T	2	Black	IDC5	5	4	Digital
CVS 1 Valve V16	V16 - T	1	Red	IDC5	5	5	Digital
Return	V16 - T	2	Black	IDC5	5	6	Digital
CVS 1 Valve V17	V17 - T	1	Red	IDC5	5	7	Digital
Return	V17 - T	2	Black	IDC5	5	8	Digital
CVS 1 Valve V18	V18 - T	1	Red	IDC5	4	1	Digital
Return	V18 - T	2	Black	IDC5	4	2	Digital
CVS 1 Valve V19	V19 - T	1	Red	IDC5	4	3	Digital
Return	V19 - T	2	Black	IDC5	4	4	Digital

Opto Site		Rack Number		Cable Group Alpha 2241C			
CVS Valves and Drivers Aid Buttons		2		CVS 2			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
CVS 2 Valve V14	V14 - T	1	Red	IDC5	4	5	Digital
Return	V14 - T	2	Black	IDC5	4	6	Digital
CVS 2 Valve V15	V15 - T	1	Red	IDC5	4	7	Digital
Return	V15 - T	2	Black	IDC5	4	8	Digital
CVS 2 Valve V16	V16 - T	1	Red	IDC5	3	1	Digital
Return	V16 - T	2	Black	IDC5	3	2	Digital
CVS 2 Valve V17	V17 - T	1	Red	IDC5	3	3	Digital
Return	V17 - T	2	Black	IDC5	3	4	Digital
CVS 2 Valve V18	V18 - T	1	Red	IDC5	3	5	Digital
Return	V18 - T	2	Black	IDC5	3	6	Digital
CVS 2 Valve V19	V19 - T	1	Red	IDC5	3	7	Digital
Return	V19 - T	2	Black	IDC5	3	8	Digital

TRW NVFEL Site 3 Upgrade Detailed Design

Opto Site		Rack Number		Cable Group Alpha 2216C			
CVS Valves and Drivers Aid Buttons		2		CVS 1 - Drivers Aid Buttons			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Bag 1 Select	CVS1-TS	11	Red	IDC5D	2	2	Digital
Bag 2 Select	CVS1-TS	14	White	IDC5D	2	4	Digital
Bag 3 Select	CVS1-TS	17	Green	IDC5D	2	6	Digital
Soak/End of Test	CVS1-TS	4	Blue	IDC5D	2	8	Digital
Return	CVS1-TS	13	Black	Term Strip	Ground		

Notes: Pins 1,3,5, and 7 on Module 2 should be tied to +5 Volts on the Power Supply via the Terminal Strip. The Return lead from TB-22/33 should be tied to Ground on the Terminal Strip

Opto Site		Rack Number		Cable Group Alpha 2216C			
CVS Valves and Drivers Aid Buttons		2		CVS 2 - Drivers Aid Buttons			
Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Bag 1 Select	CVS2-TS	11	Red	IDC5D	1	2	Digital
Bag 2 Select	CVS2-TS	14	White	IDC5D	1	4	Digital
Bag 3 Select	CVS2-TS	17	Green	IDC5D	1	6	Digital
Soak/End of Test	CVS2-TS	4	Blue	IDC5D	1	8	Digital
Return	CVS2-TS	13	Black	Term Strip	Ground		

Notes: Pins 1,3,5, and 7 on Module 1 should be tied to +5 Volts on the Power Supply via the Terminal Strip. The Return lead from TB-22/33 should be tied to Ground on the Terminal Strip

TRW NVFEL Site 3 Upgrade Detailed Design

Opto Site		Rack Number		Cable Group			
CVS Valves and Drivers Aid Buttons		2		VMIX 1 Cable			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
V Mix 1			White	IDC5D	0	1	Digital Counter
Vmix 1 Return			Black	IDC5D	0	2	Digital Counter

Opto Site		Rack Number		Cable Group			
CVS Valves and Drivers Aid Buttons		2		VMIX 2 Cable			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
V Mix 2			White	IDC5D	0	3	Digital Counter
Vmix 2 Return			Black	IDC5D	0	4	Digital Counter

Opto Site		Rack Number		Cable Group Alpha 2219/12C			
CVS Feedback		3		Barometer			

Signal Name	Source Connector	Pin Number	Wire Color	Opto-22 Module	Module Number	Module Pin Number	Module Type
Barometer Hundredths [1]	T. Strip	3	Red	IDC5D	0	1	Digital
Barometer Hundredths[2]	T. Strip	4	Black	IDC5D	0	3	Digital
Barometer Hundredths [4]	T. Strip	5	White	IDC5D	0	5	Digital
Barometer Hundredths [8]	T. Strip	6	Black	IDC5D	0	7	Digital
Return Hundredths	T. Strip	18	Grn/Blk	IDC5D	1	8	Digital
Barometer Tents [1]	T. Strip	7	Blue	IDC5D	1	1	Digital
Barometer Tents [2]	T. Strip	8	Black	IDC5D	1	3	Digital
Barometer Tents [4]	T. Strip	9	Brown	IDC5D	1	5	Digital
Barometer Tents [8]	T. Strip	10	Black	IDC5D	1	7	Digital
Return Tents	T. Strip	18	Yel/Blk	IDC5D	1	8	Digital
Barometer Units [1]	T. Strip	11	Orange	IDC5D	2	1	Digital
Barometer Units 2]	T. Strip	12	Black	IDC5D	2	3	Digital
Barometer Units [4]	T. Strip	13	Green	IDC5D	2	5	Digital
Barometer Units [8]	T. Strip	14	Red	IDC5D	2	7	Digital
Return Units	T. Strip	20	Wht/Red	IDC5D	2	8	Digital
Barometer Tens [1]	T. Strip	15	Blue	IDC5D	3	1	Digital
Barometer Tens [2]	T. Strip	16	Red	IDC5D	3	3	Digital
Barometer Tens [4]	T. Strip	17	Yellow	IDC5D	3	5	Digital
Barometer Tens [8]	T. Strip	19	Red	IDC5D	3	7	Digital
Return Tens.	T. Strip	20	Brn/Red	IDC5D	3	8	Digital

Bill of Materials

The following tables were generated as a help in determining the bill of materials needed to build the equipment. These tables are followed by a set of tables which are to be used by a purchasing agent to procure the hardware.

Hoffman Box Hardware

Hoffman Part	Analyzer	CVS Feedback	CVS Valves	Barometer
Box	A-1614CH	A-1614CH	A-1212CH	A-1212CH
Panel	A-16P14	A-16P14	A-12P12	A-12P12

Opto-22 Hardware

Opto Site	Brain	8 Rack	12 Rack	IDC5D	IDC5	ODC5 Sink	AIV	AIMA	Supply 5 Volt	Supply 24 Volt
Analyzer	1		1	6			6		1	
CVS Feedback	1		1	5 1 - Fast		2	1	1	1	1
CVS Valves	1	1		3	3				1	
Barometer	1	1		4					1	
TOTAL	4	2	2	18 1 - Fast	3	2	7	1	4	1

AMP Connector Hardware

AMP Part	Analyzer	CVS Feedback	CVS Valves	Barometer
Housing	(6) 200346-2	(2) 201345-1	(12) 1-480319-0 (pin) (12) 1-480318-0 (plug)	
Shields		(2) 204173-2		
Strain Relief Clamps	(6) 201237-1			
Jack Screws		(2) 207234-1 (2) 207235-1 (2) 201092-1 (2) 201089-1		
Guide Hardware	(12) 200389-2	(8) 201046-2		
Locking Springs	(12) 201921-1			
Pin Hoods		(2) 201364-4		
Female Pins	(48) 201580-1		(24) 60617-1	
Male Pins		(48) 201578-1	(24) 60620-1	
Crimping Tool	(1) 58305-1			
Terminal Spades	(13) 34541 Newark #: 96F287		(16) 34541	(20) 34541

Strain Relief Hardware

Usage	Analyzer	CVS Feedback	CVS Valves	Barometer
Power Cord 0.25 "	1	1	1	1
Ethernet Cable 0.25 "	1	1	1	1
0.25 Inch		4	2	
0.32 Inch			2	
0.37 Inch		1		
0.41 Inch				1
0.50 Inch		1		
0.62 Inch (Grouped)			2	

Miscellaneous Hardware

Quantity	Newark Part Number	Description
4	37F3340	Belden 17501-C3-10 - 10 Foot Power Cord
300	78N506	SPC Tech. Cable Ties 4"
300	78N507	SPC Tech Cable Ties 6"
1	84N549	Heat shrink
1	84N550	Heat Shrink
1	84N612	Heat Shrink
1	84N609	Heat Shrink
1	84N611	Heat Shrink
1	92N5987	500 Feet Blue Belden Cat 5 Ethernet Patch Cable
3	92N5994	Package of 10 RJ45 Connectors
1	89F871	Crimping Tool for Modular Connectors
1	83F3368	8 Port Ethernet Hub 10Base-T

Bill of Materials for Site 3

AMP Ordering Summary

Quantity	AMP Part Number	Description	Estimated Total Cost
6	200346-2	Connector Housing	\$25.00
2	201345-1	Connector Housing	\$25.00
12	1-480319-0	Connector Housing	\$5.00
12	1-480318-0	Connector Housing	\$5.00
2	204173-2	180 Degree Shield Pair	\$10.00
6	201237-1	Strain Relief Clamp	\$12.00
2	207234-1	Jack Screw	\$5.00
2	207235-1	Jack Screw	\$5.00
2	201092-1	Jack Screw	\$5.00
2	201089-1	Jack Screw	\$5.00
12	200389-2	Guide Hardware (Center)	\$12.00
8	201046-2	Guide Hardware (Corner)	\$12.00
12	201921-1	Locking Springs	\$12.00
2	201364-4	Pin Hoods	\$10.00
48	201580-1	Female Pins	\$18.00
24	60617-1	Female Pins	\$9.00
48	201578-1	Male Pins	\$18.00
24	60620-1	Male Pins	\$9.00
1	58305-1	Expensive Crimping Tool	\$550.00
1 Package	34541	Terminal Spades (100 per Package)	\$22

Suggested Source	Sterling Electronics 1615 West 2200 South Salt Lake City Utah 84119 Voice: 801-972-5444 Fax: 801-972-5498
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Opto-22 Parts Ordering Summary

QUANTITY	PART NUMBER	DESCRIPTION	Est. Total Cost
4	SNAP-B3000-ENET	Analog/Digital Ethernet Brain	\$2780.00
2	SNAP-B8MC	8 Module rack with extra terminal block for field wiring	\$208.00
2	SNAP-B12MC	12 Module rack with extra terminal block for field wiring	\$266.00
18	SNAP-IDC5D	SNAP 4-Channel 2.5 - 28 VDC Input, 5 VDC Logic	\$702.00
1	SNAP-IDC5-FAST	SNAP 4-Channel 2.5 – 16VDC Input, Fast	\$100.00
3	SNAP-IDC5	SNAP 4-Channel 10-32 VDC Input, 5 VDC Logic	\$126.00
2	SNAP-ODC5SNK	SNAP 4-Channel 5-60 VDC Output, 5 VDC Logic Sink	\$84.00
7	SNAP-AIV	SNAP 2-Channel analog voltage input -10VDC to +10VDC	\$1092.00
1	SNAP-AIMA	SNAP 2 Channel analog current input -20MA to +20MA	\$364.00
4	SNAP-PS5	5 Volt Power Supply	\$800.00
1	SNAP-PS24	24 Volt Power Supply	\$200.00
14	SNAP-STRAP	Opto Accessory Module Jumper Strap	\$126.00
5	SNAP-WIRESTRAP	Opto Accessory Wiring Jumper Strap	\$28.00

Suggested Source: Opto-22 Sales and Marketing Department
43044 Business Park Drive
Temecula, CA 92590-3614
Voice: 800-452-6786
sales@opto22.com

Hoffman Box Ordering Summary

Quantity	Hoffman Part Number	Description	Estimated Total Cost
2	A-1614CH	CH Box 16.00x14.00x6.00	\$240.00
2	A-1212CH	CH Box 12.00x12.00x6.00	\$180.00
2	A-16P14	Painted Steel Panel 14.75x12.88	\$28.00
2	A-12P12	Painted Steel Panel 10.75x10.75	\$20.00

Suggested Source	Lyle Williams Company 4768 Brown Street Salt Lake City, UT 84107 Voice: 801-268-4300 FAX: 801-266-4333
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Miscellaneous Parts Summary

Quantity	Newark Part Number	Description	Estimated Total Cost
14	83F3332	Bud Cable Gland	\$28.00
3	83F3334	Bud Cable Gland	\$7.00
1	83F3335	Bud Cable Gland	\$3.00
5	83F3336	Bud Cable Gland	\$15.00
1	33F760	Round Punch	\$25.00
1	33F762	Round Punch	\$32.00
1	33F776	Round Punch	\$32.00
1	33F736	Round Punch	\$40.00
4	37F3340	Belden 17501-C3-10 - 10 Foot Power Cord	\$25.00
3 Packages	78N506	SPC Tech. Cable Ties 4" 100 Per Package	\$10.00
3 Packages	78N507	SPC Tech Cable Ties 6" 100 Per Package	\$15.00
1	84N549	Heat shrink	\$21.00
1	84N550	Heat Shrink	\$25.00
1	84N609	Heat Shrink	\$19.00
1	84N611	Heat Shrink	\$21.00
1	92N5987	500 Feet Blue Belden Cat 5 Ethernet Patch Cable	\$70.00
3 Packages	92N5994	Package of 10 RJ45 Connectors	\$15.00
1	89F871	Crimping Tool for Modular Connectors	\$25.00
1	83F3368	8 Port Ethernet Hub 10Base-T	\$75.00
Suggested Source: Newark Electronics 1-800-463-9275			

Wire Bill of Materials

Alpha Wire Number	Description	Gage	#Pair	Total Length
2219/19C	Shielded Twisted Pairs	22	19	50 Feet
2219C	Shielded Twisted Pairs	22	9	50 Feet
2241C	Shielded Twisted Pair	18	1	500 Feet
2216C	Shielded Twisted Pairs	22	6	100 Feet
2219/12C	Shielded Twisted Pairs	22	12	50 Feet